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(54) **GAS TURBINE FACILITY WITH SUPERCRITICAL FLUID "CO2" RECIRCULATION**

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    See application file for complete search history.

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(57) **ABSTRACT**

The gas turbine facility **10** of the embodiment includes a combustor **20** combusting fuel and oxidant, a turbine **21** rotated by combustion gas, a heat exchanger **23** cooling the combustion gas, a heat exchanger **24** removing water vapor from the combustion gas which passed through the heat exchanger **23** to regenerate dry working gas, and a compressor **25** compressing the dry working gas until it becomes

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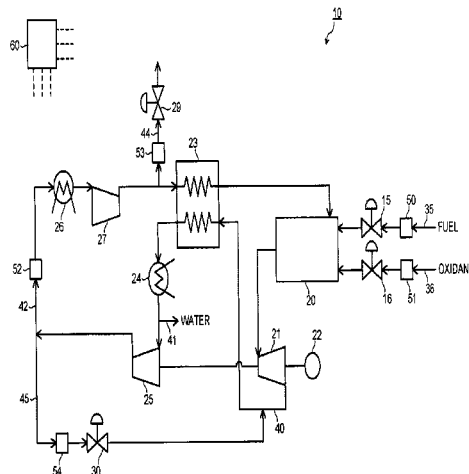
supercritical fluid. Further, the gas turbine facility **10** includes a pipe **42** guiding a part of the dry working gas from the compressor **25** to the combustor **20** via the heat exchanger **23**, a pipe **44** exhausting a part of the dry working gas to the outside, and a pipe **45** introducing a remaining part of the dry working gas exhausted from the compressor **25** into a pipe **40** coupling an outlet of the turbine **21** and an inlet of the heat exchanger **23**.

13 Claims, 3 Drawing Sheets

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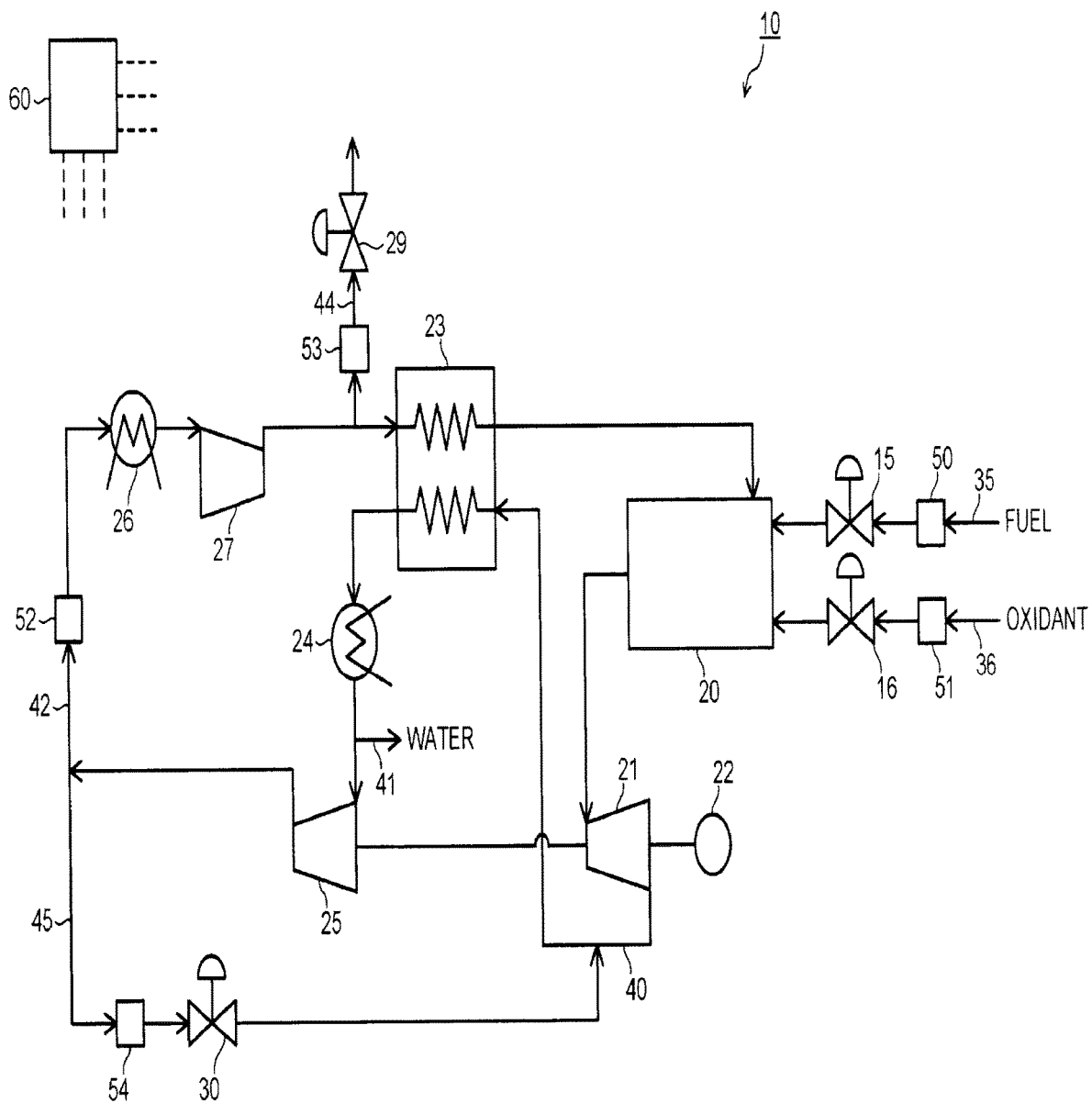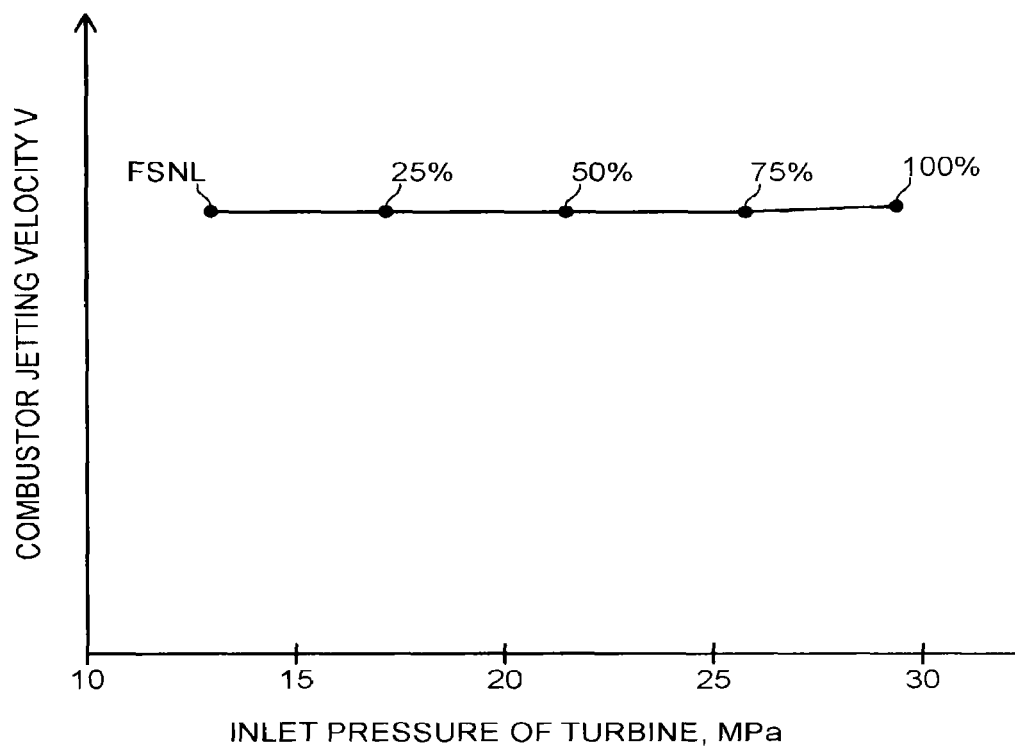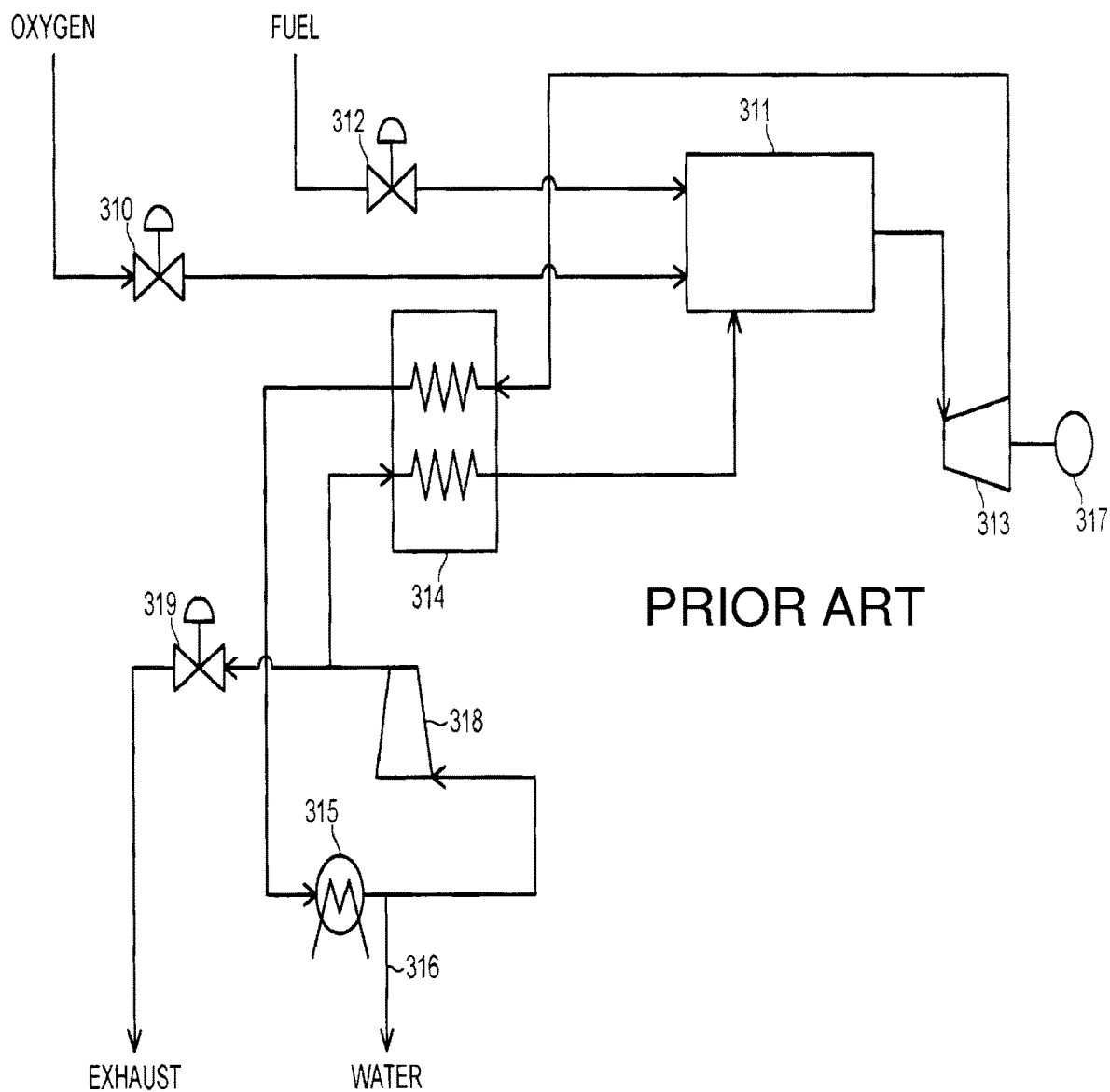
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FIG. 1

FIG. 2

FIG. 3

OXYGEN   FUEL

312

310

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313   317

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PRIOR ART

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318

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EXHAUST   WATER

GAS TURBINE FACILITY WITH SUPERCRITICAL FLUID "CO2" RECIRCULATION

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. patent application Ser. No. 14/456,233, filed Aug. 11, 2014, which is based upon and claims the benefit of priority from Japanese Patent Application No. 2013-175933, filed on Aug. 27, 2013; the entire contents of which are incorporated herein by reference.

FIELD

Embodiments described herein relate generally to a gas turbine facility.

BACKGROUND

Increasing efficiency of power generation plants is in progress in response to demands for reduction of carbon dioxide, resource conservation, and the like. Specifically, increasing temperature of working fluid of a gas turbine and a steam turbine, employing a combined cycle, and the like are actively in progress. Further, research and development of collection techniques of carbon dioxide are in progress.

FIG. 3 is a system diagram of a conventional gas turbine facility in which a part of carbon dioxide generated in a combustor is circulated as working fluid. As illustrated in FIG. 3, oxygen separated from an air separator (not illustrated) is regulated in flow rate by a flow rate regulating valve 310 and is supplied to a combustor 311. Fuel is regulated in flow rate by a flow rate regulating valve 312 and is supplied to the combustor 311. This fuel is, for example, hydrocarbon.

The fuel and oxygen react (combust) in the combustor 311. When the fuel combusts with oxygen, carbon dioxide and water vapor are generated as combustion gas. The flow rates of fuel and oxygen are regulated to be of a stoichiometric mixture ratio in a state that they are completely mixed.

The combustion gas generated in the combustor 311 is introduced into a turbine 313. The combustion gas which performed an expansion work in the turbine 313 passes through a heat exchanger 314 and then further through a heat exchanger 315. When passing through the heat exchanger 315, the water vapor condenses into water. The water passes through a pipe 316 and is discharged to the outside. Note that a generator 317 is coupled to the turbine 313.

Dry working gas (carbon dioxide) separated from water vapor is compressed by a compressor 318. A part of the compressed carbon dioxide is regulated in flow rate by a flow rate regulating valve 319 and is exhausted to the outside. The rest of the carbon dioxide is heated in the heat exchanger 314 and is supplied to the combustor 311.

Here, in the gas turbine facility, turbine load control is performed from a full speed no load (FSNL) to a rated value. Thus, the flow rate of working fluid introduced into the turbine 313 varies. The pressure of the working fluid in this gas turbine facility is at high pressure, and thus the volumetric flow rate of the working fluid in the compressor 318 is small. Accordingly, as the compressor 318, an axial compressor is not suitable, and a centrifugal compressor is used.

A part of the carbon dioxide supplied to the combustor 311 is introduced into a combustion zone together with the fuel and oxygen. The rest of the carbon dioxide is used to cool wall surfaces of the combustor 311 and dilute the combustion gas. Then, the carbon dioxide introduced into the combustor 311 is introduced into the turbine 313 together with the combustion gas.

In the above-described system, an amount of carbon dioxide equivalent to the amount of carbon dioxide generated by combusting fuel and oxygen in the combustor 311 is exhausted to the outside of the system. The carbon dioxide exhausted to the outside of the system is collected by, for example, a recovery apparatus. Further, for example, it is also possible to utilize the exhausted carbon dioxide for pushing out residual oil from an underground rock formation of an oil field. On the other hand, the carbon dioxide left in the system circulates through the system.

In the above-described conventional gas turbine facility, flame formed in the combustor 311 is affected by, for example, a jetting velocity of carbon dioxide jetted into the combustor 311 (hereinafter referred to as a combustor jetting velocity V).

This combustor jetting velocity V is defined by following equation (1).

$$V = G \times T \times R \times Z / (P \times A) \qquad (1)$$

Here, G is a volumetric flow rate of carbon dioxide flowing into the combustor 311, T is a temperature of carbon dioxide flowing into the combustor 311, R is a gas constant, and Z is a coefficient of compressibility. Further, P is a pressure of carbon dioxide flowing into the combustor 311, and A is a total opening area of an opening passed through by carbon dioxide which flowed into the combustor 311.

As described above, the flame is affected by the combustor jetting velocity V. Accordingly, when the turbine load control is performed in the gas turbine facility, for example, it is preferred to control this combustor jetting velocity V in an appropriate range so as to achieve stabilization of the flame.

However, in the centrifugal compressor used as the above-described compressor 318, for example, inlet guide vanes similar to that in the axial compressor is not provided, and thus it is difficult to perform flow rate control in a wide range. Accordingly, when the turbine load changes, it is difficult to control the combustor jetting velocity V in an appropriate range.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a system diagram of a gas turbine facility of an embodiment.

FIG. 2 is a diagram illustrating the relation between an inlet pressure of a turbine and a combustor jetting velocity V in each load state in the gas turbine facility of the embodiment.

FIG. 3 is a system diagram of a conventional gas turbine facility in which a part of carbon dioxide generated in a combustor is circulated as working fluid.

DETAILED DESCRIPTION

In one embodiment, a gas turbine facility includes a combustor combusting fuel and oxidant, a turbine rotated by combustion gas exhausted from the combustor, a heat exchanger cooling the combustion gas exhausted from the turbine, and a water vapor remover removing water vapor

from the combustion gas which passed through the heat exchanger to regenerate dry working gas therefrom.

Moreover, the gas turbine facility has a compressor compressing the dry working gas until it becomes supercritical fluid, a combustor introduction pipe guiding a part of the dry working gas of supercritical fluid exhausted from the compressor to the combustor via the heat exchanger, an exhaust pipe branched from the combustor introduction pipe on an upstream side of the heat exchanger to exhaust a part of the dry working gas flowing through the combustor introduction pipe to the outside, and a bypass pipe introducing a remaining part of the dry working gas of supercritical fluid exhausted from the compressor into a pipe coupling an outlet of the turbine and an inlet of the heat exchanger.

Hereinafter, embodiments will be described with reference to drawings.

FIG. 1 is a system diagram of a gas turbine facility 10 of an embodiment. As illustrated in FIG. 1, the gas turbine facility 10 has a combustor 20 combusting fuel and oxidant. A pipe 35 supplying fuel to the combustor 20 is provided with a flow rate regulating valve 15 for regulating a flow rate of fuel. A pipe 36 supplying oxidant to the combustor 20 is provided with a flow rate regulating valve 16 for regulating a flow rate of oxidant. Note that the flow rate regulating valve 16 functions as an oxidant flow rate regulating valve.

Here, as the fuel, for example, hydrocarbon such as natural gas or methane, or coal gasification gas can also be used. As the oxidant, oxygen is used. This oxygen is obtained by, for example, separating from the atmosphere by an air separating apparatus (not illustrated).

The combustion gas exhausted from the combustor 20 is guided to a turbine 21. This turbine 21 is rotated by combustion gas. For example, a generator 22 is coupled to this turbine 21. Note that the combustion gas exhausted from the combustor 20 mentioned here contains combustion product, generated by combustion of fuel and oxidant, and dry working gas (carbon dioxide), which will be described later, supplied to the combustor 20 and exhausted together with the combustion product from the combustor 20.

The combustion gas exhausted from the turbine 21 is cooled by passing through a heat exchanger 23 interposed in a pipe 40. The combustion gas which passed through the heat exchanger 23 further passes through a heat exchanger 24 interposed in the pipe 40. By passing through the heat exchanger 24, water vapor contained in the combustion gas is removed, and dry working gas is regenerated from the combustion gas. Here, by passing through the heat exchanger 24, the water vapor condenses into water. This water passes through a pipe 41 for example and is discharged to the outside. Note that the heat exchanger 24 functions as a water vapor remover removing water vapor.

It is preferred that no excess oxidant (oxygen) or fuel remain in the combustion gas exhausted from the combustor 20. Accordingly, the flow rates of fuel and oxygen supplied to the combustor 20 are regulated to be of a stoichiometric mixture ratio (equivalence ratio). Thus, the components of the dry working gas are mostly carbon dioxide. Note that the dry working gas also includes the case where, for example, a minute amount of carbon monoxide or the like is mixed in.

The dry working gas is guided to a compressor 25 by the pipe 40. The dry working gas is compressed by the compressor 25 until it becomes supercritical fluid. At an outlet of the compressor 25, pressure of the dry working gas is, for example, 8 MPa to 9 MPa, and temperature of the dry working gas is, for example, 35 to 45° C. Note that the supercritical fluid refers to a state under a temperature and a pressure equal to or higher than a critical point.

Here, as the compressor 25, for example, a centrifugal compressor is used. The compressor 25 is, for example, coupled coaxially to the turbine 21 so as to prevent overspeeding of the turbine 21. In this case, the compressor 25 rotates constantly at a rated rotation speed of the turbine 21 when the turbine 21 is at a rated value. The centrifugal compressor has a small surge margin with respect to increase in pressure ratio. Thus, when the rotation speed is constant, the centrifugal compressor is preferred to be operated with a volumetric flow rate and a pressure ratio which are constant.

Further, in order to keep the pressure at the outlet of the compressor 25 at a certain supercritical pressure for example, the pressure at an inlet of the compressor 25 is also at a constant value. When the pressure at the inlet of the compressor 25 is constant, the pressure at an outlet of the turbine 21 is constant. This is preferred also in view of sealing characteristics of the turbine 21 and stable use of the heat exchangers 23, 24. Note that in order to maintain the pressure at the outlet of the compressor 25 constant, it is necessary to regulate a flow rate of dry working gas flowing through a pipe 45, which will be described later.

A part of the dry working gas of supercritical fluid exhausted from the compressor 25 passes through a pipe 42 and is guided to the combustor 20. This pipe 42 functions as a combustor introduction pipe. In the pipe 42, a cooler 26 for cooling the dry working gas of supercritical fluid is interposed. The dry working gas of supercritical fluid maintains a pressure equal to or higher than the pressure of the critical point by passing through the cooler 26, and is at a temperature lower than the temperature of the critical point. Thus, after passing through the cooler 26, the dry working gas exits the state of supercritical fluid and becomes liquid.

In the pipe 42 on a downstream side of the cooler 26, a pump 27 pressurizing the dry working gas which became liquid is interposed. The pump 27 pressurizes, for example, the dry working gas which became liquid according to a turbine load. The pump 27 is controlled in rotation speed by an inverter motor for example. The dry working gas which became liquid is pressurized by the pump 27 and also its temperature becomes equal to or higher than the temperature of the critical point. Thus, the dry working gas which became liquid passes through the pump 27 to thereby become the dry working gas of supercritical fluid again.

In the pump 27, for example, in order to supply the dry working gas at a predetermined flow rate and pressure to the combustor 20, rotation speed control is carried out by, for example, an inverter so as to make it pass setting points of the predetermined flow rate and pressure.

Here, the reason for making the dry working gas which passed through the cooler 26 become liquid while keeping a pressure equal to or higher than the pressure of the critical point is, for example, to prevent damage due to cavitation occurring when a two-layer flow of gas-liquid mixture enters the pump 27 under the condition that gas and liquid can exist together, such as a condition equal to or lower than the critical point. Further, by making it become liquid, condensation heat is not deprived, allowing operation while maintaining cycle efficiency.

Further, by turbine load control, a flow rate of the dry working gas exhausted from the pump 27 and an outlet pressure of the pump 27 change widely. In the turbine 21, the combustion gas becomes a choked flow, and hence its swallowing capacity (SWC) becomes constant. Thus, the following equation (2) is satisfied.

$$SWC = G_t \times (T_t)^{1/2}/P_t = \text{constant} \qquad \text{equation (2)}$$

Here, G_t is a volumetric flow rate of the combustion gas at an inlet of the turbine 21, T_t is a temperature of the combustion gas at the inlet of the turbine 21, and P_t is a pressure of the combustion gas at the inlet of the turbine 21.

For example, in order to increase the pressure of the combustion gas supplied to the turbine 21, if the flow rate of the combustion gas is determined, the fuel flow rate and the oxidant flow rate are increased to raise the temperature of the combustion gas. However, when the pump 27 is not provided, there is almost no surge input margin of the centrifugal compressor which is the compressor 25, and thus it cannot withstand the pressure increase thereof. Accordingly, by having the pump 27, a system which withstands the pressure increase is realized.

A pipe 44 exhausting a part of the dry working gas flowing through the pipe 42 to the outside is branched from the pipe 42 between the pump 27 and the heat exchanger 23. This pipe 44 functions as an exhaust pipe. The pipe 44 is provided with a flow rate regulating valve 29 for regulating the flow rate of the dry working gas to be exhausted. Note that the flow rate regulating valve 29 functions as an exhaust flow rate regulating valve.

The dry working gas exhausted from the pipe 44 is collected by, for example, a recovery apparatus. Further, for example, it is also possible to utilize the exhausted dry working gas to push out residual oil from an underground rock formation of an oil field. For example, an amount of carbon dioxide equivalent to the amount of carbon dioxide generated by combusting fuel and oxygen in the combustor 20 is exhausted from the pipe 44. Note that the dry working gas other than the dry working gas exhausted from the pipe 44 is guided to the combustor 20 and circulates through the system.

On the downstream of the branching part of the pipe 44, the pipe 42 passes through the heat exchanger 23 and communicates with the combustor 20. In the heat exchanger 23, the dry working gas of supercritical fluid flowing through the pipe 42 obtains a heat quantity from the combustion gas exhausted from the turbine 21 and is heated thereby. The dry working gas passing through the pipe 42 and being introduced into the combustor 20 is, for example, jetted into a combustion zone together with the fuel and oxidant from the upstream side of the combustor 20, or jetted into a downstream side of a combustion zone in a combustor liner from a dilution hole or the like after cooling the combustor liner.

Here, a jetting velocity to the combustor 20 of the dry working gas guided to the combustor 20 via the pipe 42 is preferred to be almost constant irrespective of the turbine load. The jetting velocity is the combustor jetting velocity V defined by the above-described equation (1). This combustor jetting velocity V is set so that a recirculation zone which contributes to flame stability is formed in an appropriate range of the combustion zone. The combustor jetting velocity V being almost constant refers to, for example, a range of ±10% with an average combustor jetting velocity in each turbine load as its center.

The total opening area A of the opening passed through by dry working gas (carbon dioxide) which flowed into the combustor 20 is constant. Accordingly, when the combustor jetting velocity V is set almost constant irrespective of the turbine load, the mass flow rate of the dry working gas supplied to the combustor changes by the turbine load, but the volumetric flow rate becomes almost constant irrespective of the turbine load.

The remaining part of the dry working gas of supercritical fluid exhausted from the compressor 25 passes through a

pipe 45 and is introduced into the pipe 40 coupling the outlet of the turbine 21 and an inlet of the heat exchanger 23. The pipe 45 functions as a bypass pipe. The pipe 45 is provided with a flow rate regulating valve 30 for regulating a flow rate of the dry working gas of supercritical fluid to be introduced into the pipe 40. When the rotation speed of the compressor 25 is constant, in order to maintain the pressure at the outlet of the compressor 25 constant, the pressure at the inlet of the compressor 25 needs to be constant. Accordingly, the flow rate of the dry working gas to be bypassed is regulated by the flow rate regulating valve 30. Note that the flow rate regulating valve 30 functions as a bypass flow rate regulating valve.

Further, the gas turbine facility 10 has a flow rate detecting unit 50 detecting the flow rate of fuel flowing through the pipe 35, a flow rate detecting unit 51 detecting the flow rate of oxidant flowing through the pipe 36, a flow rate detecting unit 52 detecting the flow rate of dry working gas flowing through the pipe 42, a flow rate detecting unit 53 detecting the flow rate of dry working gas flowing through the pipe 44, and a flow rate detecting unit 54 detecting the flow rate of dry working gas flowing through the pipe 45. Each flow rate detecting unit is constituted of, for example, a flowmeter of venturi type, Coriolis type, or the like.

Here, the flow rate detecting unit 50 functions as a fuel flow rate detecting unit, the flow rate detecting unit 51 as an oxidant flow rate detecting unit, the flow rate detecting unit 52 as a combustor introduction flow rate detecting unit, the flow rate detecting unit 53 as an exhaust flow rate detecting unit, and the flow rate detecting unit 54 as a bypass flow rate detecting unit.

The gas turbine facility 10 has a control unit 60 which controls openings of the respective flow rate regulating valves 16, 29, 30 based on detection signals from the respective flow rate detecting units 50, 51, 52, 53, 54. This control unit 60 mainly has, for example, an arithmetic unit (CPU), a storage unit such as a read only memory (ROM) and a random access memory (RAM), an input/output unit, and so on. The CPU executes various types of arithmetic processing using, for example, programs, data, and the like stored in the storage unit.

The input/output unit inputs an electrical signal from an outside device or outputs an electrical signal to an outside device. Specifically, the input/output unit is connected to, for example, the respective flow rate detecting units 50, 51, 52, 53, 54 and the respective flow rate regulating valves 15, 16, 29, 30, and so on in a manner capable of inputting/outputting various signals. Processing executed by this control unit 60 is realized by, for example, a computer apparatus or the like.

Next, operations related to flow rate regulation of fuel, oxygen, and dry working gas (carbon dioxide) supplied to the combustor 20 will be described with reference to FIG. 1.

While the gas turbine facility 10 is operated, an output signal from the flow rate detecting unit 50 is inputted to the control unit 60 via the input/output unit. Based on the inputted output signal, the oxygen flow rate needed for making the equivalence ratio be 1 is calculated in the arithmetic unit by using programs, data, and so on stored in the storage unit. Note that the fuel flow rate is controlled by regulating an opening of the flow rate regulating valve 15 based on, for example, a required gas turbine output.

Subsequently, based on an output signal from the flow rate detecting unit 51 which is inputted from the input/output unit, the control unit 60 outputs an output signal for regulating the valve opening from the input/output unit to the flow rate regulating valve 16 so that the calculated carbon dioxide flow rate flows through the pipe 36.

Next, in the arithmetic unit of the control unit **60**, based on an output signal from the flow rate detecting unit **50** which is inputted from the input/output unit, the flow rate of dry working gas (carbon dioxide) of supercritical fluid introduced into the combustor **20**, the flow rate of the dry working gas of supercritical fluid exhausted from the pipe **44**, and the flow rate of the dry working gas of supercritical fluid bypassing via the pipe **45** are calculated. Note that calculations of these flow rates can be performed simultaneously as the above-described calculation of the oxygen flow rate. Further, the flow rate of the dry working gas can also be calculated based on an output signal from the flow rate detecting unit **51**.

Here, the flow rate of the dry working gas (carbon dioxide) introduced into the combustor **20** is calculated so that the combustor jetting velocity V becomes a set value. Note that the flow rate of the dry working gas exhausted from the pipe **44** is, as described above, the amount equivalent to the amount of carbon dioxide generated by combusting fuel and oxygen in the combustor **20**. For example, when the fuel flow rate decreases, the flow rate of the dry working gas bypassed via the pipe **45** increases. On the other hand, when the fuel flow rate increases, the flow rate of the dry working gas bypassed via the pipe **45** decreases.

Note that the compressor **25** is coupled coaxially to the turbine **21**. Thus, when the turbine **21** is at a rated value, the compressor **25** rotates constantly at a rated rotation speed of the turbine **21**. Further, the pressure at the inlet of the compressor **25** is constant, and the pressure of the dry working gas at the outlet of the compressor **25** is a constant supercritical pressure. Thus, the flow rate of the dry working gas exhausted from the compressor **25** becomes constant.

Subsequently, based on output signals from the flow rate detecting units **52**, **53**, **54** inputted from the input/output unit, the control unit **60** outputs output signals for regulating the valve openings from the input/output unit to the flow rate regulating valves **29**, **30** so that the respective calculated flow rates of the dry working gas flow through the pipes **42**, **44**, **45**. Note that in the structure illustrated in FIG. **1**, those detected in the flow rate detecting unit **52** are flow rates of the dry working gas introduced into the combustor **20** and the dry working gas exhausted from the pipe **44**.

Here, the pump **27** is controlled by the control unit **60** to be at a rotation speed by which the flow rates of the dry working gas introduced into the combustor **20** and the dry working gas exhausted from the pipe **44** can be drawn in. Further, the pressure of the dry working gas at an outlet of the pump **27** is a pressure required at an inlet of the combustor **20**, in other words, the inlet of the turbine **21**.

Here, for example, when the flow rate of the dry working gas introduced into the combustor **20** is decreased, the control unit **60** controls the flow rate regulating valve **30** for example.

Then, the dry working gas flowing through the pipe **42** after it is branched to the pipe **44** passes through the heat exchanger **23** and introduced into the combustor **20**.

By performing the controls as described above, even when the turbine load changes, the combustor jetting velocity V can be maintained almost constant in the appropriate range. Thus, the recirculation zone is formed in the appropriate range of the combustion zone, and flame stabilization in the combustor **20** can be achieved.

Here, FIG. **2** is a diagram illustrating the relation between an inlet pressure of the turbine **21** and the combustor jetting velocity V in each load state in the gas turbine facility **10** of the embodiment. Note that the outlet pressure of the turbine **21** in the illustration is 3 MPa. Further, in FIG. **2**, for

example, FSNL is a full speed no load state, and 25% indicates that the turbine load is 25%.

As illustrated in FIG. **2**, even when the turbine load changes, the combustor jetting velocity V is maintained almost constant.

As described above, in the gas turbine facility **10** of the embodiment, the pressure of the dry working gas at the outlet of the compressor **25** is a constant supercritical pressure. Then, the pump **27** is provided in the pipe **42**, and the pipe **45** bypassing a part of the dry working gas to the pipe **40** is provided. Even when the turbine load changes by them, they enable to maintain the combustor jetting velocity V substantially constant in the appropriate range and achieve flame stabilization in the combustor **20**.

In the above-described embodiment, even when the turbine load changes, the combustor jetting velocity can be maintained in the appropriate range, and flame stabilization can be achieved.

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

What is claimed is:

1. A gas turbine facility, comprising:
   a combustor combusting fuel and oxidant;
   a turbine rotated by combustion gas exhausted from the combustor;
   a heat exchanger cooling the combustion gas exhausted from the turbine;
   a water vapor remover removing water vapor from the combustion gas which passed through the heat exchanger to regenerate dry working gas therefrom;
   a compressor compressing the dry working gas until it becomes supercritical fluid;
   a combustor introduction pipe guiding a part of the supercritical fluid exhausted from the compressor to the combustor via the heat exchanger;
   a pump configured to pressurize the dry working gas;
   an exhaust pipe branched from the combustor introduction pipe on an upstream side of the heat exchanger to exhaust a part of the dry working gas flowing through the combustor introduction pipe to the outside; and
   a bypass pipe introducing a remaining part of the supercritical fluid exhausted from the compressor into a pipe coupling extending from an outlet of the turbine to an inlet of the heat exchanger.

2. The gas turbine facility according to claim **1**, wherein the pump is controlled in rotation speed independently of a rotation speed of the turbine to vary a flow rate and a pressure of the dry working gas directed to the heat exchanger.

3. The gas turbine facility according to claim **2**, wherein the pump is interposed in the combustor introduction pipe between a branch part of the exhaust pipe and the cooler to increase pressure of the dry working gas flowing through the combustor introduction pipe according to a turbine load.

4. A gas turbine facility, comprising:
   a combustor combusting fuel and oxidant;
   a turbine rotated by combustion gas exhausted from the combustor;

a heat exchanger cooling the combustion gas exhausted from the turbine;

a water vapor remover removing water vapor from the combustion gas which passed through the heat exchanger to regenerate dry working gas therefrom;

a compressor compressing the dry working gas until it becomes supercritical fluid;

a combustor introduction pipe guiding a part of the supercritical fluid exhausted from the compressor to the combustor via the heat exchanger;

an exhaust pipe branched from the combustor introduction pipe on an upstream side of the heat exchanger to exhaust a part of the dry working gas flowing through the combustor introduction pipe to the outside;

a bypass pipe introducing a remaining part of the supercritical fluid exhausted from the compressor into a pipe extending from an outlet of the turbine to an inlet of the heat exchanger; and

a bypass flow rate regulating valve provided in the bypass pipe to regulate the flow rate of the supercritical fluid flowing through the bypass pipe.

5. The gas turbine facility according to claim **4**, wherein the bypass flow rate regulating valve is configured to provide a substantially constant volumetric flow rate of the dry working gas to the compressor.

6. A gas turbine facility, comprising:

a combustor combusting fuel and oxidant;

a turbine rotated by combustion gas exhausted from the combustor;

a heat exchanger cooling the combustion gas exhausted from the turbine;

a water vapor remover removing water vapor from the combustion gas which passed through the heat exchanger to regenerate dry working gas therefrom;

a pump configured to pressurize the dry working gas;

a combustor introduction pipe guiding a part of the dry working gas to the combustor via the heat exchanger, the pump being controlled in rotation speed independently of a rotation speed of the turbine to vary a flow rate and a pressure of the dry working gas directed to the heat exchanger;

a centrifugal compressor coupled coaxially to the turbine and compressing the dry working gas until it becomes supercritical fluid, and

a cooler interposed in the combustor introduction pipe on an upstream side of a branch part of an exhaust pipe branched from the combustor introduction pipe on an upstream side of the heat exchanger to cool the supercritical fluid flowing through the combustor introduction pipe.

7. The gas turbine facility according to claim **6**, wherein the the combustor introduction pipe receiving the part of the dry working gas from the compressor as supercritical fluid.

8. The gas turbine facility according to claim **7**, wherein the exhaust pipe is arranged to exhaust a part of the dry working gas flowing through the combustor introduction pipe to the outside.

9. The gas turbine facility according to claim **8**, further comprising a bypass pipe introducing a remaining part of the dry working gas exhausted from the compressor into a pipe coupling an outlet of the turbine and an inlet of the heat exchanger.

10. The gas turbine facility according to claim **9**, further comprising:

a fuel flow rate detecting unit interposed in a first pipe, which the fuel supplied to the combustor flows through, to detect a flow rate of the fuel;

an oxidant flow rate detecting unit interposed in a second pipe, which the oxidant supplied to the combustor flows through, to detect a flow rate of the oxidant;

an oxidant flow rate regulating valve provided in the pipe, which the oxidant flows through, to regulate the flow rate of the oxidant;

a combustor introduction flow rate detecting unit interposed in the combustor introduction pipe to detect a flow rate of the supercritical fluid flowing through the combustor introduction pipe;

an exhaust flow rate detecting unit interposed in the exhaust pipe to detect a flow rate of the supercritical fluid flowing through the exhaust pipe;

an exhaust flow rate regulating valve provided in the exhaust pipe to regulate the flow rate of the supercritical fluid flowing through the exhaust pipe;

a bypass flow rate detecting unit interposed in the bypass pipe to detect a flow rate of the supercritical fluid flowing through the bypass pipe;

a bypass flow rate regulating valve provided in the bypass pipe to regulate the flow rate of the supercritical fluid flowing through the bypass pipe; and

a control unit controlling openings of the oxidant flow rate regulating valve, the exhaust flow rate regulating valve, and the bypass flow rate regulating valve based on detection signals from the fuel flow rate detecting unit, the oxidant flow rate detecting unit, the combustor introduction flow rate detecting unit, the exhaust flow rate detecting unit, and the bypass flow rate detecting unit.

11. The gas turbine facility according to claim **9**, further comprising a bypass flow rate regulating valve provided in the bypass pipe to regulate the flow rate of the dry working gas flowing through the bypass pipe.

12. The gas turbine facility according to claim **11**, wherein the bypass flow rate regulating valve is configured to provide a substantially constant volumetric flow rate of the dry working gas to the compressor.

13. The gas turbine facility according to claim **6**, wherein the pump is interposed in the combustor introduction pipe between the branch part of the exhaust pipe and the cooler to increase pressure of the dry working gas flowing through the combustor introduction pipe according to a turbine load.

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